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INTEGRATING SUSTAINABILITY INTO STEM: A PROJECT BASED APPROACHED

Joseph P. Harney

Polytechnic Summit
6.6.17

MY BACKGROUND BEFORE WENTWORTH

- Undergraduate degree in Physics-UMass
  - Worked as a construction worker and general carpenter.
- Graduate degree in Applied Physics (inorganic chemistry research)-UMass
  - Facilitated study group (FSG) instructor of organic chemistry

*Also taught and designed classes from high school through university level

HOW FAR HAS SCIENCE EDUCATION COME?

- Traditional classroom focused on the instructor
- Tends to be a disconnect from college to industry with trades and engineering.
- WIT has tried to alleviate this by requiring coops and EPIC

WENTWORTH'S CORE VALUES

Our core values reflect that we are student-centered, that we are passionate for real-life, hands-on teaching and learning, and that innovation and creativity are at the center of what we do. We express these three core values as:

Students first

The world is our classroom

Think without a box

EPIC LEARNING

- Externally collaborated, Project-based, Interdisciplinary Curricula
- Nationally recognized as the university of choice for EPIC learning by 2032

“Empowers both faculty and students to take risks, experiment, and find the deeper purpose of their work”

HOW WILL YOU MAKE CHEMISTRY EPIC AT WIT?

- In a comparable climate, a man engineered a conventional radiant flooring system, and repurposed hot water solar panels to heat his house <u>not</u> just his potable house water.

- To put it into economic terms- He is not saving a few hundred dollars a year, he is saving thousands

- Cheap, easily accessible materials, perfect for teaching, and industry (1st and 3rd world)

SOLAR HEATING PLAN FOR ANY HOME

by GARY REYSA

Slash your home heating bills with this exciting solar project. If you can build a deck, you can build this super system!

It's time to take advantage of solar heat to reduce your dependence on fossil fuels and lower your heating bills. This simple, yet effective, system can be utilized in almost any home. Because the solar collectors and the heat storage tank for the system are built into a small new outbuilding, you don't need to remodel your home completely to use solar heat. On sunny days (or even partly sunny days) the collectors add heat to the storage tank. When the house needs heat, hot water from the storage tank is transferred to the house via an underground pipe into a radiant floor heating system. (See illustration on Page 62.) The new building that houses our collectors is a storage shed, but yours could be a studio, playhouse or workshop.

Advantages of this approach:

- The collectors are mounted at ground level, where they are much easier to build and maintain.
- The collectors can be oriented and tilted for maximum heat gain.
- The collectors and building can share a structure in such a way that the material costs and time to build are reduced for both the collectors and the shed.
- The collectors look good integrated with the shed (at far right below).
- You don't have to find a space for a large thermal storage tank in the house.
- The steeply tilted or vertical collectors located close to the ground benefit from light reflected off the ground, particularly when it's covered with snow. And, vertical or near-vertical collectors are less prone to overheating in the summer.

Considerations

There are many ways to build this system, but remember these design guidelines to ensure that your system works like it should:

- The collectors should face within 30 degrees of true south and should not be shaded by trees or structures during the three hours before and after solar noon. Be sure to check carefully

Mother Earth News December 2007/ January 2008

Home Power 124 April/May 2008

INTERDISCIPLINARY AND PROJECT-BASED

- Thermodynamics: Heat capacity, emissivity, rate of heat transfer
- Stoichiometry: Combustion, fuel efficiency
- Engineering and Construction: Design and construction of custom tank and panel.

*Projects can be done along side in-class lectures, examples, case studies and quiz/test questions.

ELEPHANT IN THE ROOM!

How do you teach the required curriculum, add projects and hands-on experience to the class, without adding extra work?!?

A TECHNIQUE FROM MY FORMER FSG MEETINGS

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ATTENDANCE POLICY:
Attendance is required for all labs. Attendance will be taken at the start of most lecture classes, by way of homework/quiz. If you are late to class, I will not mark you absent, you will have just missed an assignment. On days that a quiz is given, you can be late, but the quizzes will be collected after a predetermined time. Refer to WIT Student Handbook, WIT's guidelines will be enforced for all other major issues.

- All students get to use their references and calculators. They are assigned a set of recommended problem and 1 required mastery question to turn in. I have tried to set up class more like the work place. We have a routine:
- Day 1: Collect previously assigned mastery HW question.
- Day 2: Pass back graded homework to study.
- Day 3: Quiz/assign next HW.

*We use current, *real-work subject matter* for *inquiry* based learning

EXAMPLES OF INQUIRY QUESTIONS

- If a cubic box holds 40 gallons of water, what is the length of any of the sides of the box, in feet? (Home heating)
- How much energy is produced by the absorption of 10 moles of blue light over a square meter? Solar/LEDs
- How many grams of carbon dioxide are produced when 15 gallons of octane are combusted? (Petro industry)
- How much work is needed to electrolyze of 1 gallon of water? (Fuel Cells)

HOW I FIT THE PROJECT COMPONENT INTO CHEMISTRY

GRADING POLICY:

Midterm*	15%
Final Exam* (cumulative)	15%
Homework	10%
Laboratories	20%
Project	10%
Quizzes	30%
	100%

*Note: Your cumulative Tests and Final exam grade must be a passing grade (> 59.9%) in order to earn a passing grade for the course.

- There are normally 11 labs. I have taken one out and we use the lab time to engineer 1 piece of the solar project per semester.
- Some of the later semester quizzes and homework are put into the project category, as well.
- Max. 16 students per lab. I split the classes between the last two weeks, so that I can devote more attention (4 groups of students)

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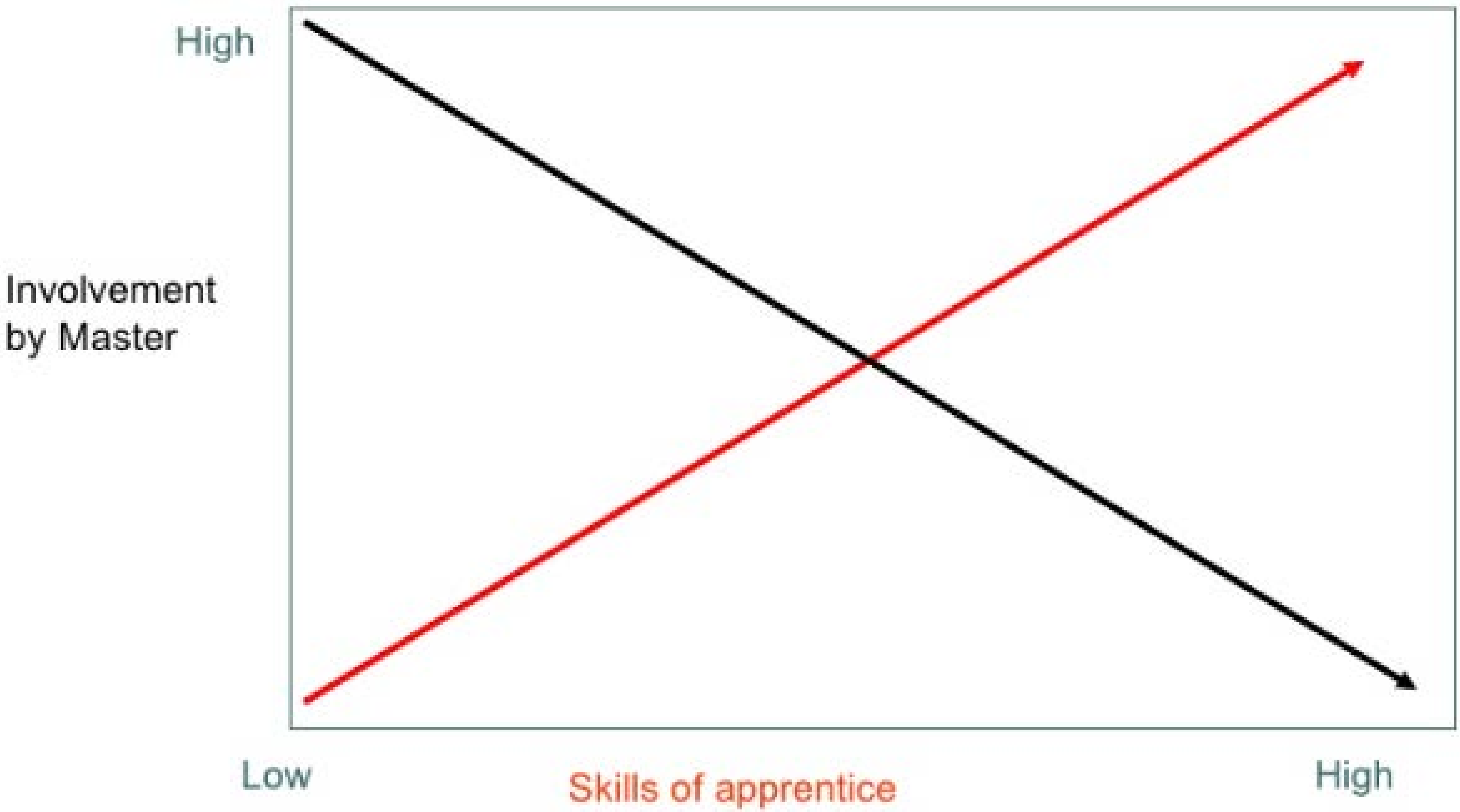
MASTER PRACTITIONER: APPRENTICE RELATIONSHIP



Daniel Pratt

https://www.slideshare.net/mharttrup/pratt-5-teaching-perspectives

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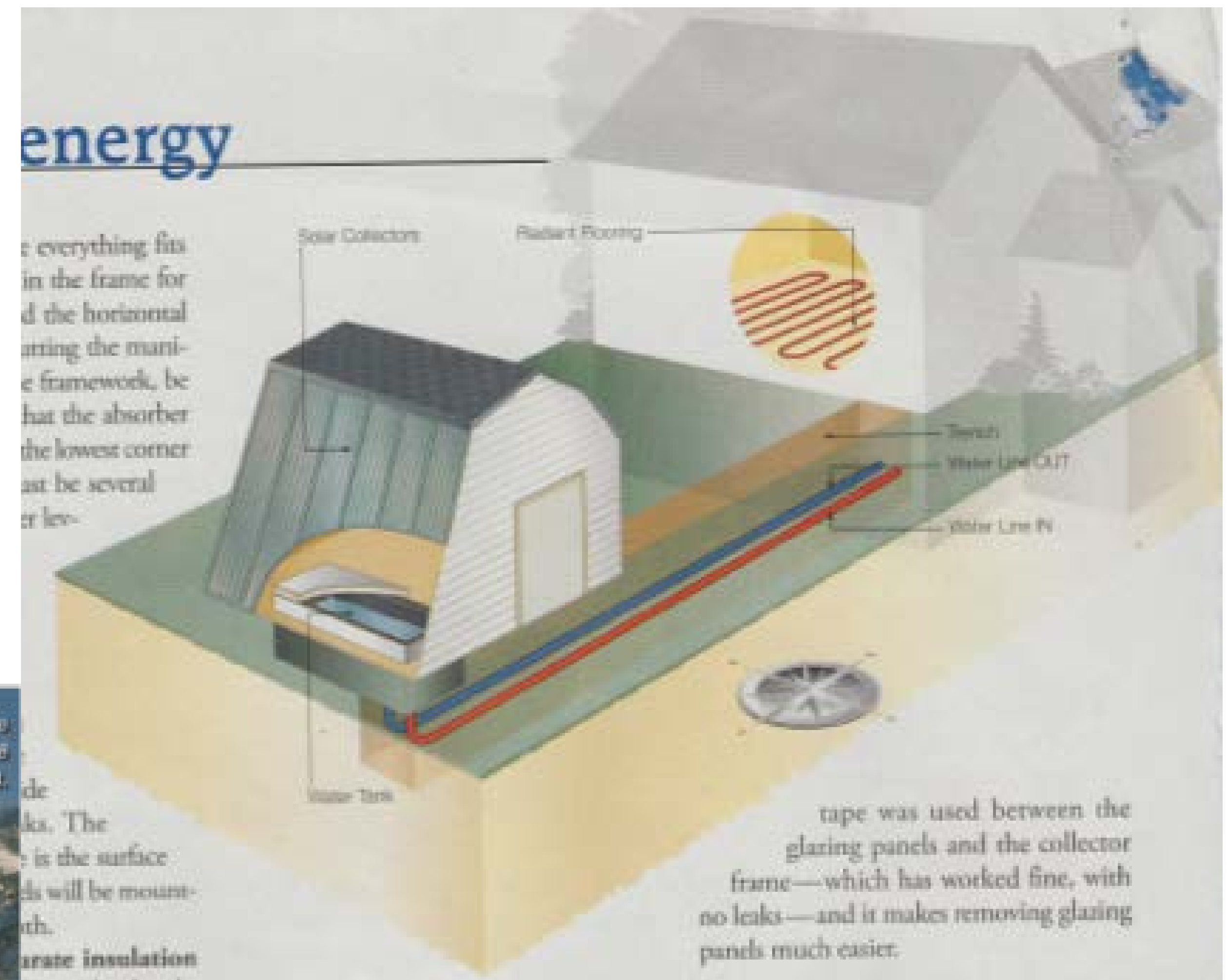
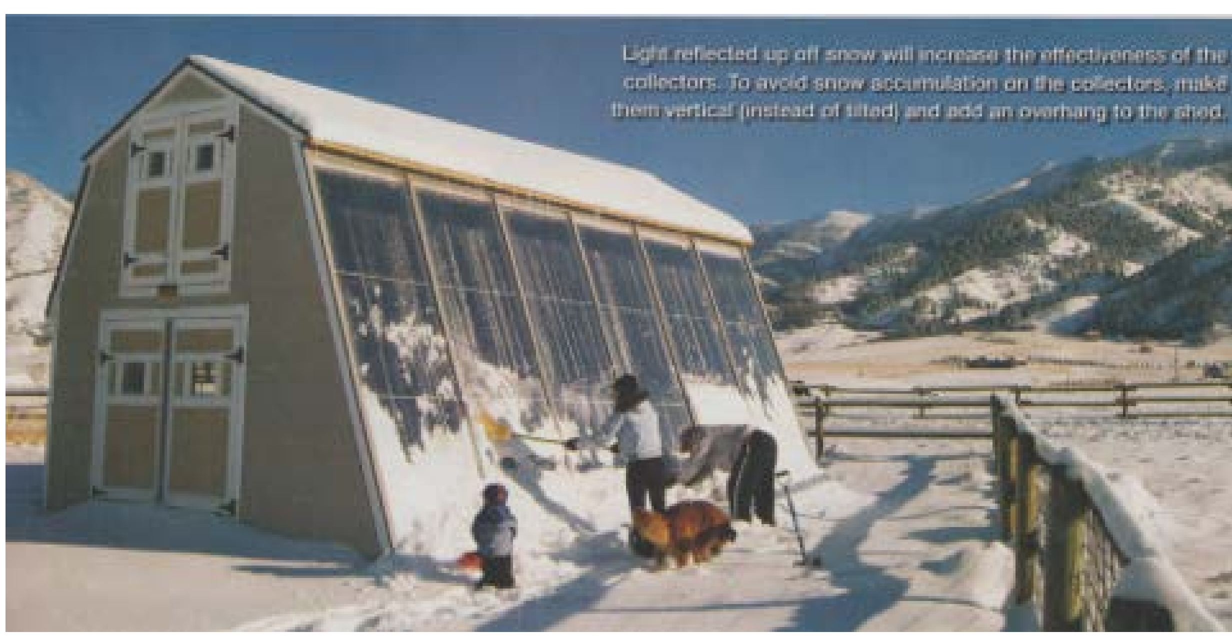
THE STUDENTS WILL BUILD THIS SYSTEM - PIECE BY PIECE

1. Learning tool
2. Hands-on experience
3. Display for campus
4. Future data collection





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THERMAL STORAGE TANK

All supplies can be found at hardware store lumber yard or Home Depot.

After reenforcing the wood, a pond liner is used.

Properly seal the inserted hot and cold pipes.

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FALL 2016

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SPRING 2017

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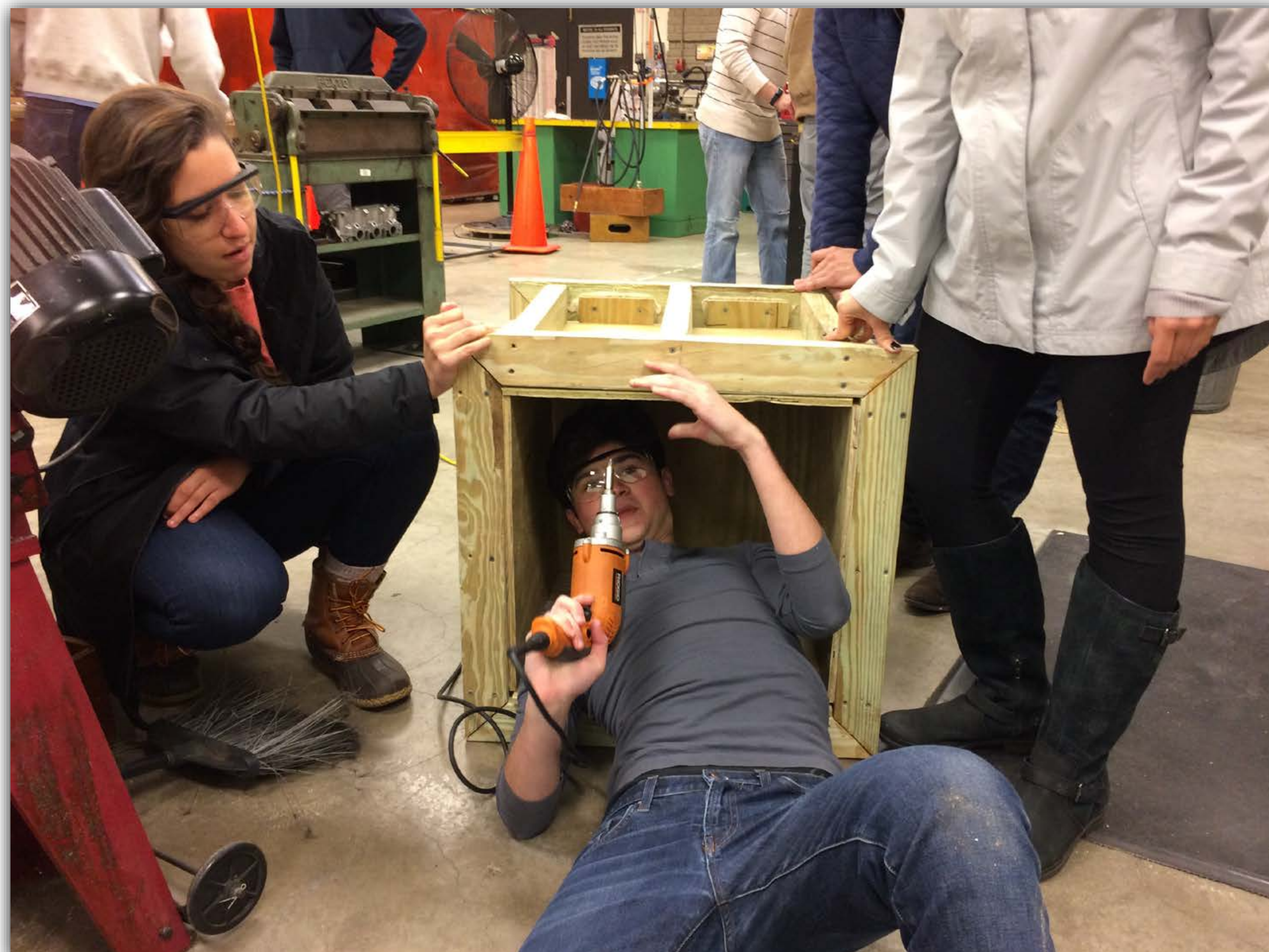


NOTICE

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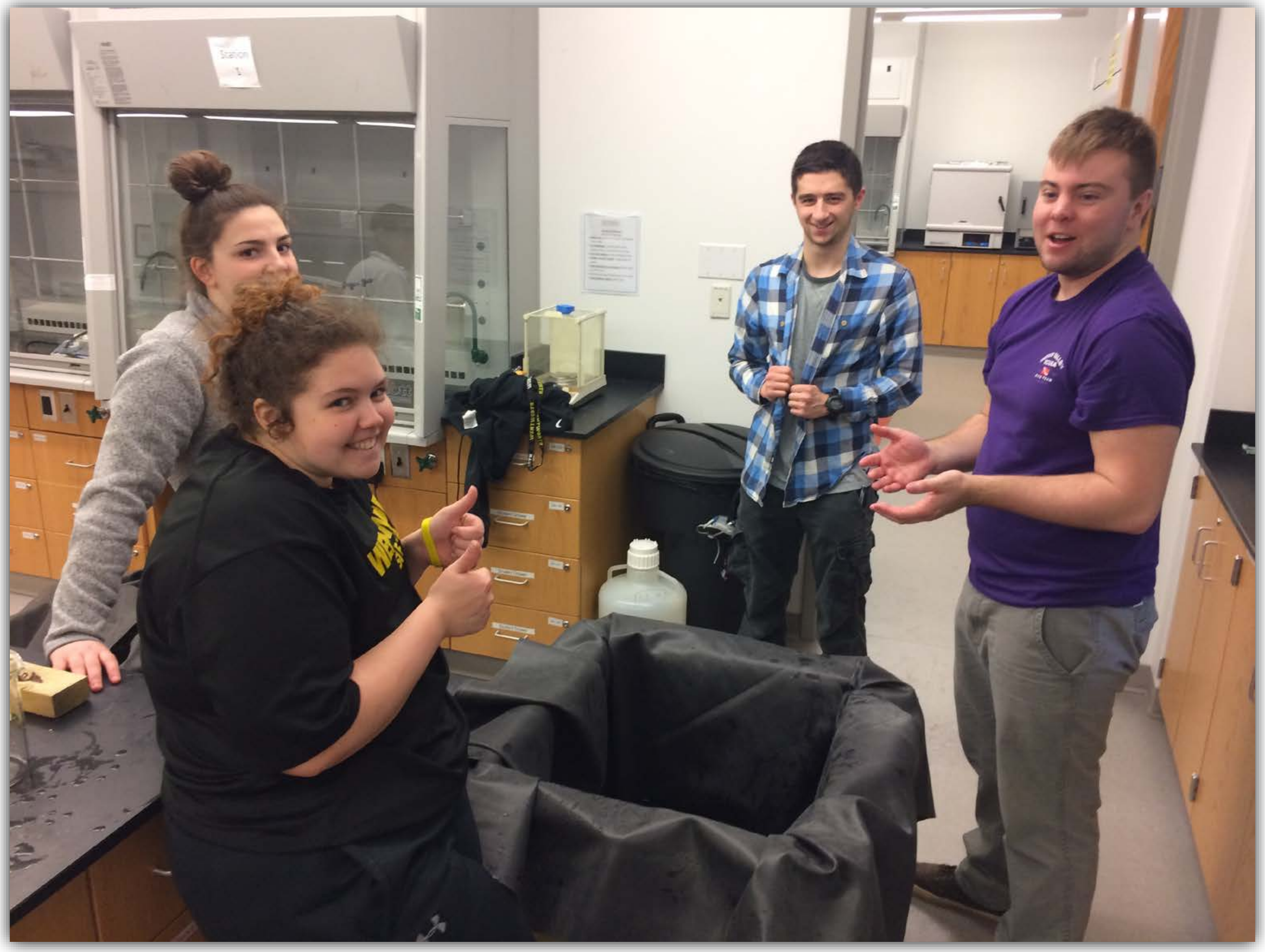

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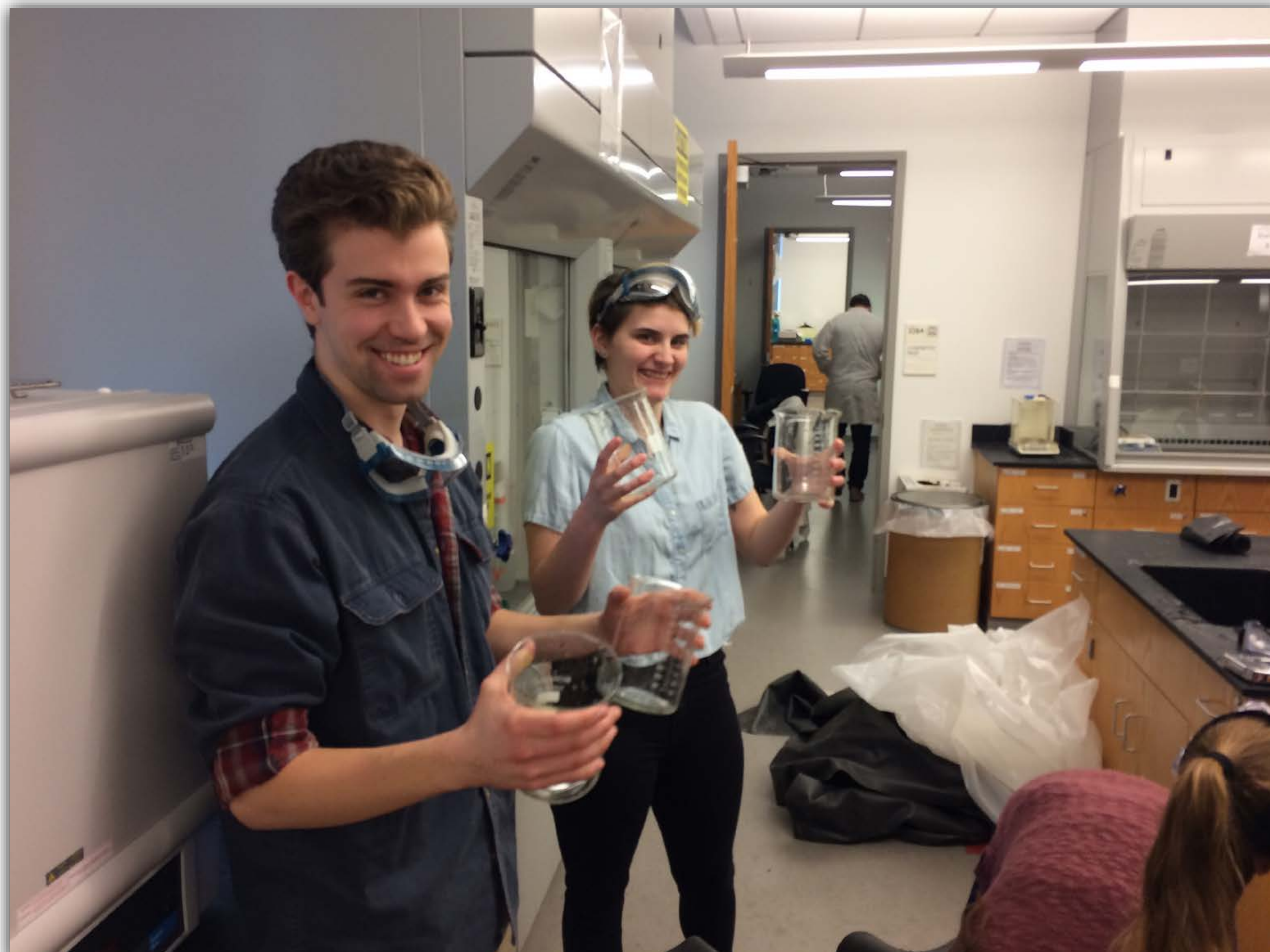

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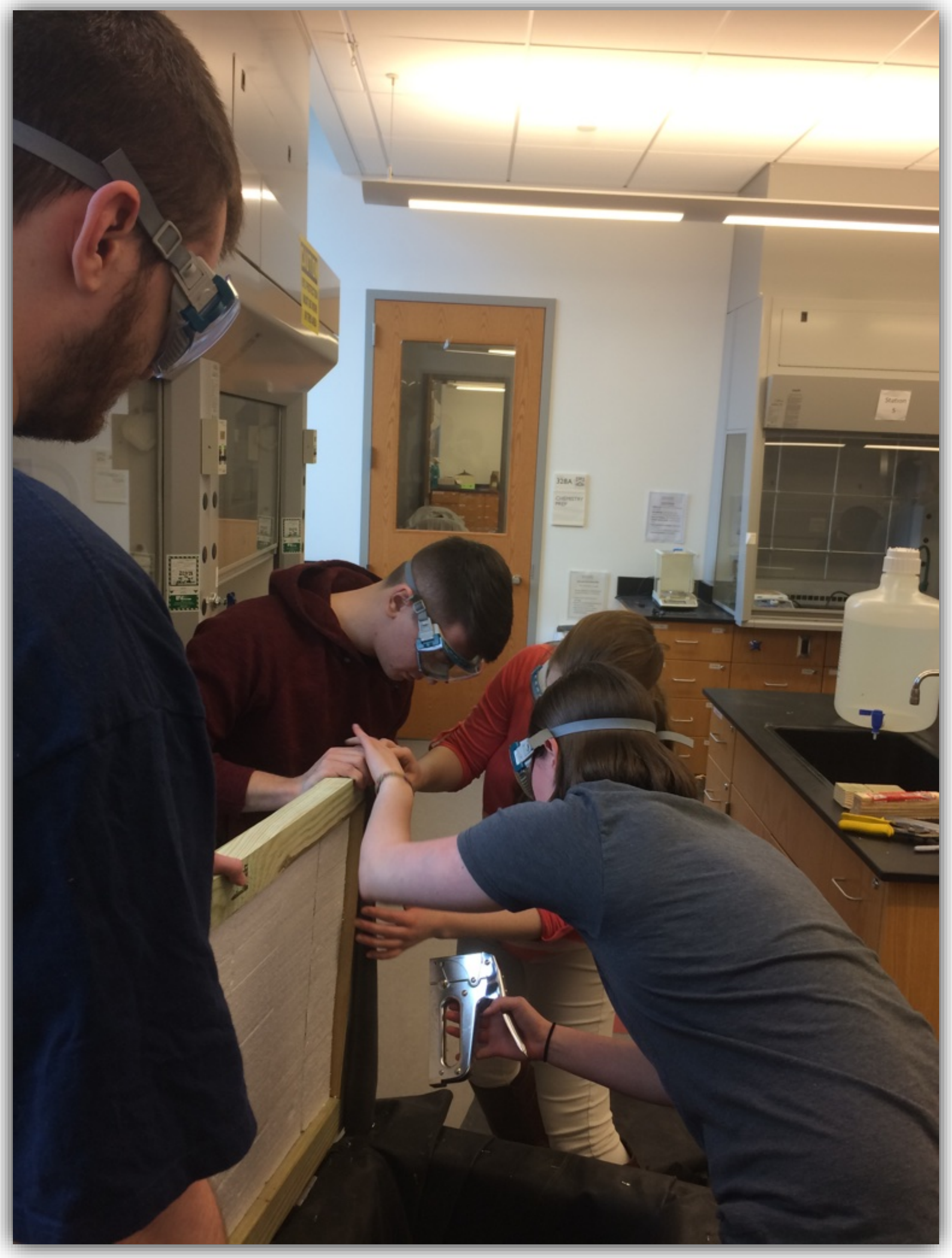

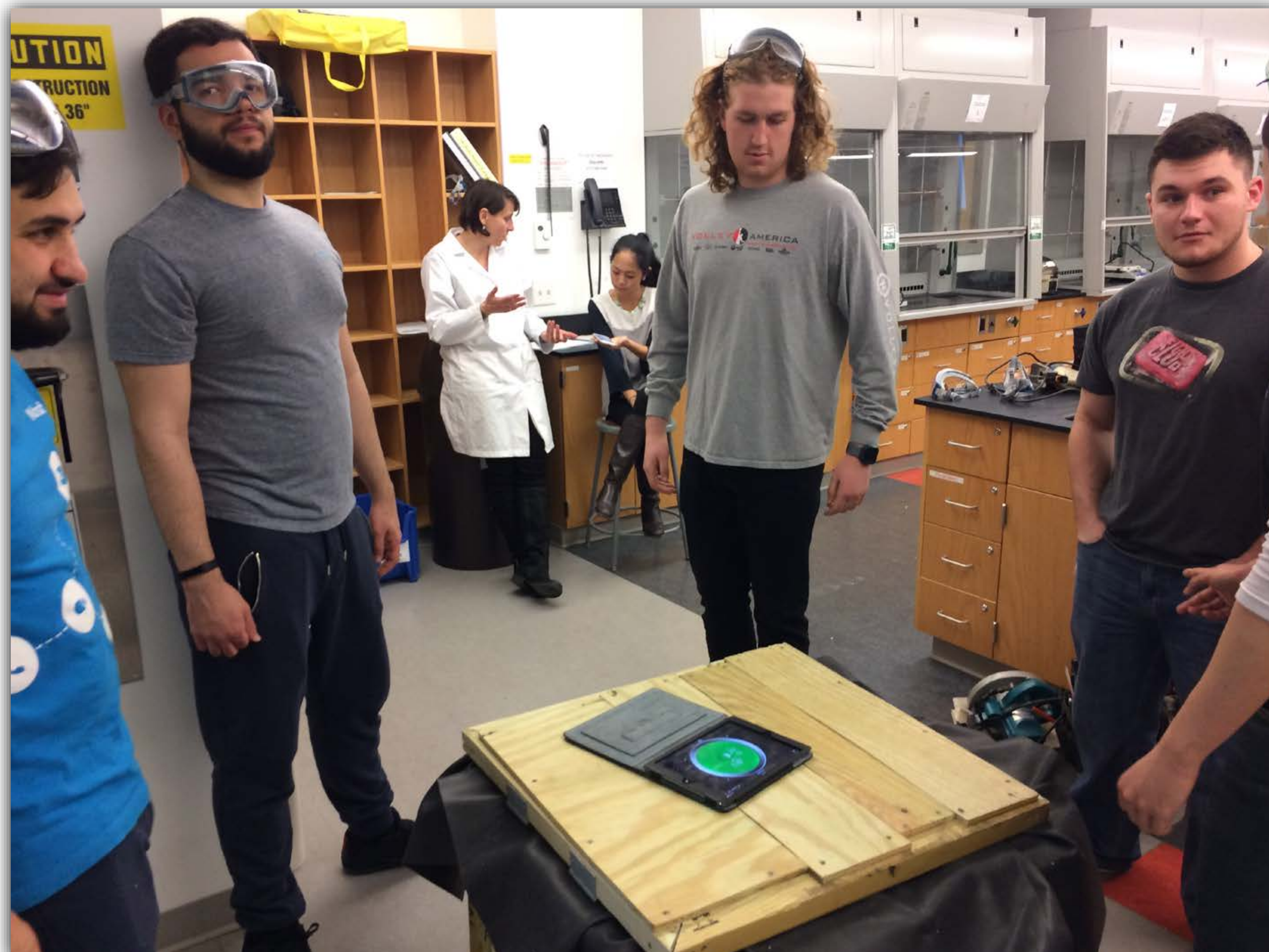

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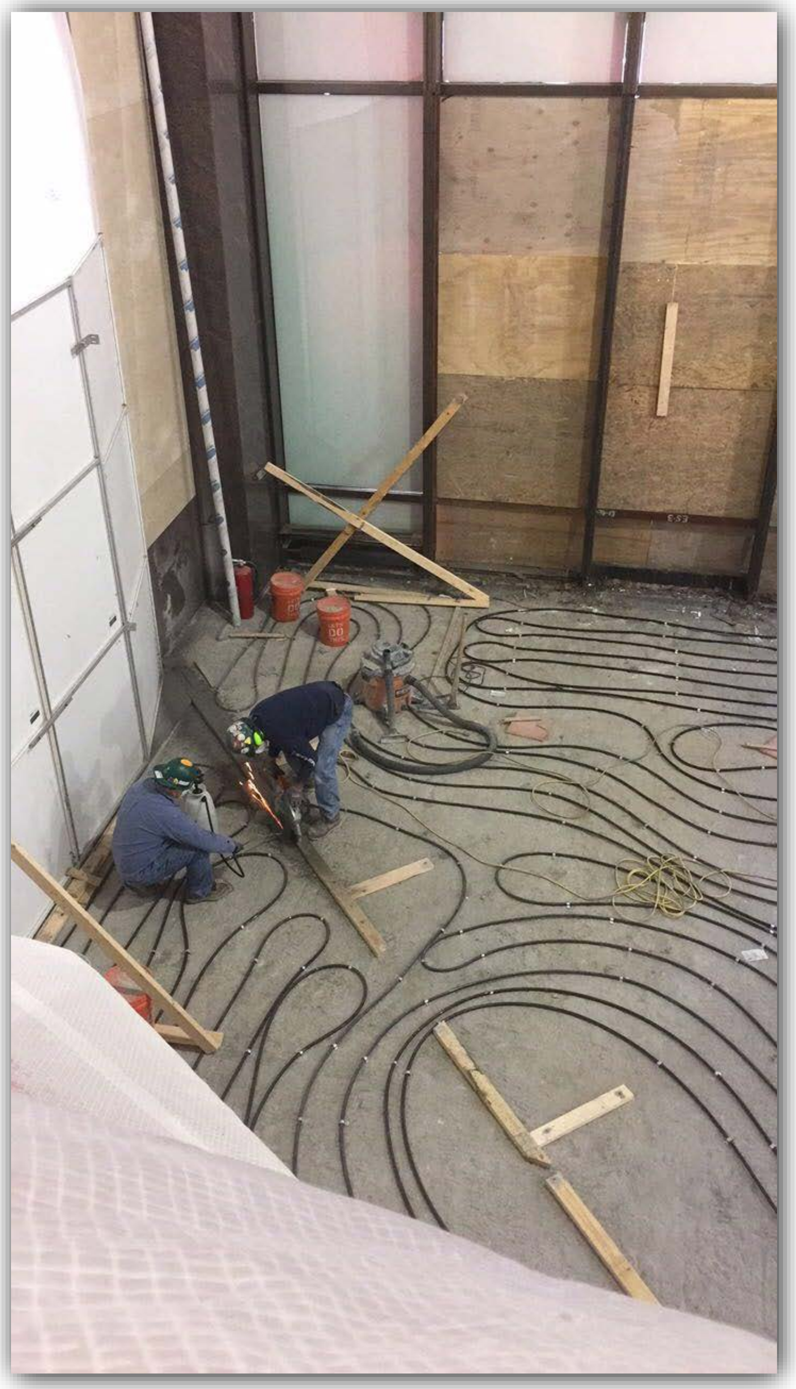
MY STUDENT'S PREVIOUS COOP



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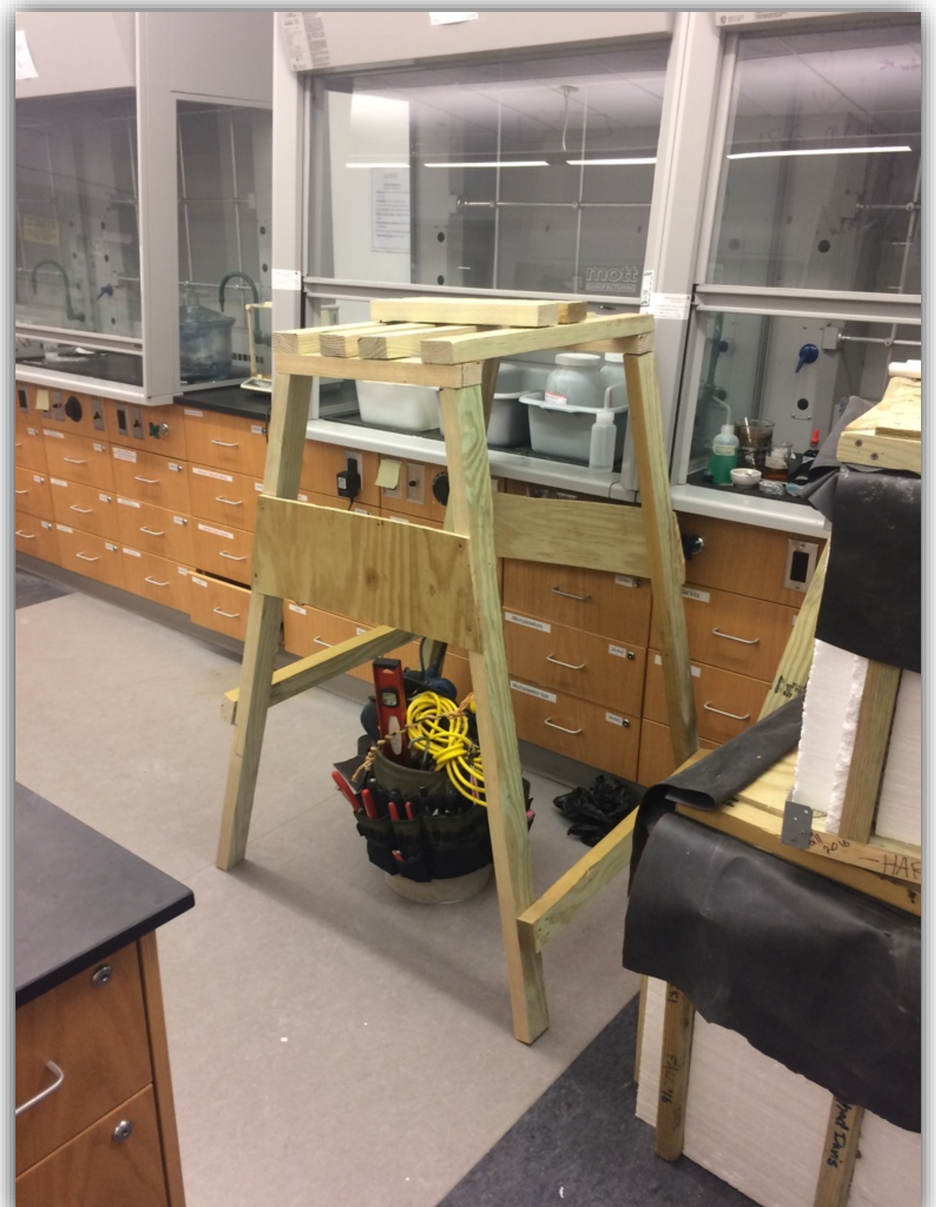
LOOKING AHEAD
FALL '17, SP '18

- Recycling center project
- Build the next part of the home heating project
- I will be teaching chemistry for construction workers
- I have developed a new Energy Storage course
- Tesla (External collaboration)



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SCHOLARLY

- A regular boiler comes on throughout the night, but the amount of power is very large in short bursts.
- If the energy demands of a home or business could be anticipated, then there should be no reason why you could not store the daytime energy with a less intensive power supply (the sun).

*Find energy demand and scale up using data

House hold water consumption	Degree change to heat water
(L)	(K)
400	20
Liters per furnace cycle	Energy to heat 1 liter 20 K
(L)	(J)
8.33	8.37E+04
Number of time furnace kicks on in 1 day	Energy to heat 1 cycle
48	(J)
Time in between furnace kickon	6.97E+05
(Mins)	Energy consumption for 1 day
30	(J)
	3.35E+07

CONCLUSIONS

In my classes, students are taught how to learn, ask appropriate questions, and inquire about the best way to solve problems. I force math, and specifically dimensional analysis at the beginning of the semester, and make sure that they know how to use their references to begin a problem.

CONCLUSIONS

Having the students built it together piece by pieceto feel a part of something larger than themselves. They gain hands-on experience, communication within a group, and standard trades/industry practices

*It is my hope to diminish the disconnect between college and workplace.

CONCLUSIONS

By the end of the semester, when the project is being built, they can do it themselves. This has not been possible for me in a traditional classroom.

Inquiry based teaching with FSG (master/apprentice) strategies and hands-on practical questions are incorporated into the required chemistry curriculum to ensure I am not over worked.

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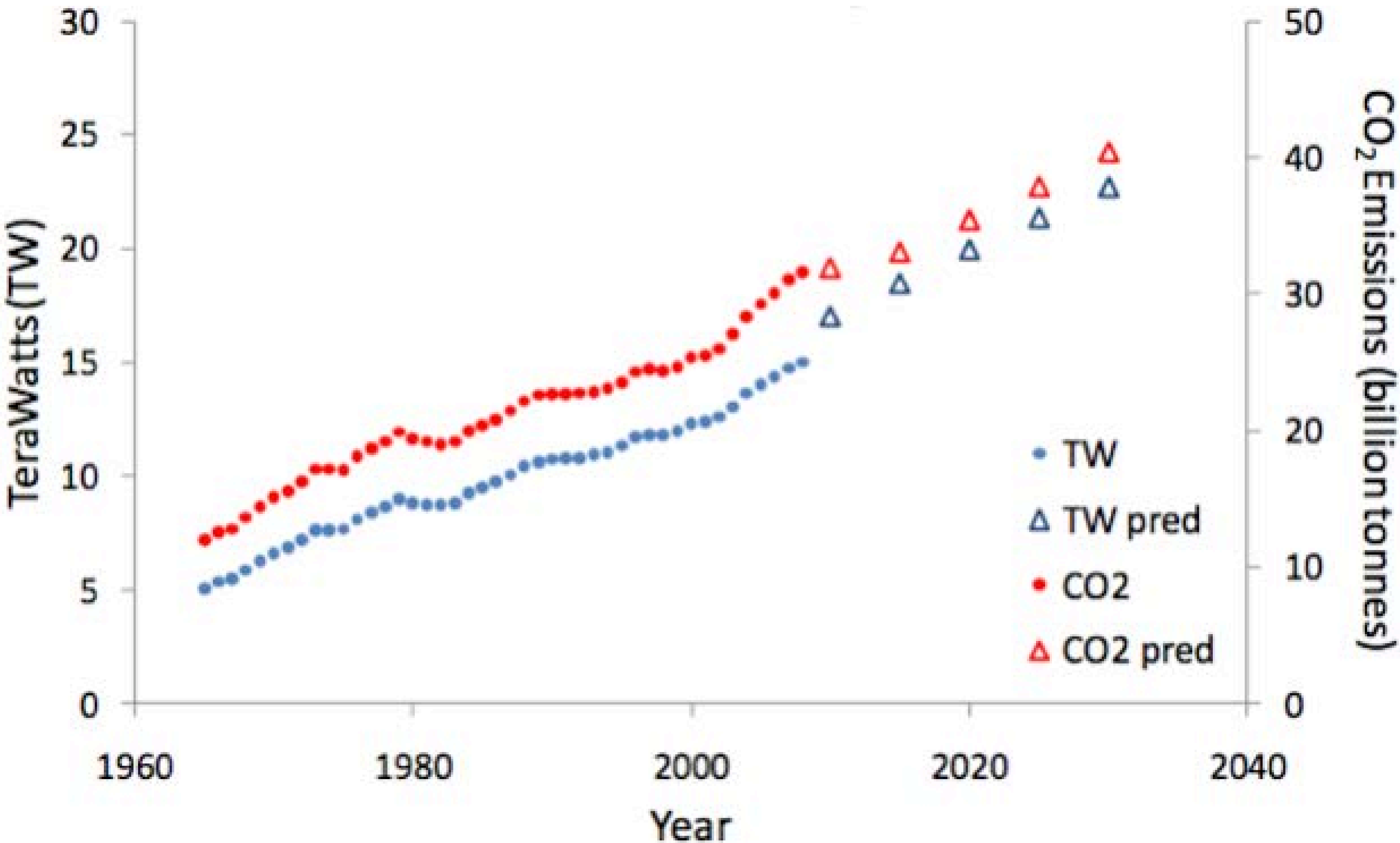
THANK YOU

NEXT SLIDES ARE FOR QUESTIONS

HOW WE BEGIN OUR THERMODYNAMICS LECTURE



International Energy Outlook 2009 (http://www.eia.doe.gov/oiaf/ieo/index.html) Statistical review of world energy, annual review by BP 2009 (http://www.bp.com/productlanding.do?categoryId=6929&contentId=7044622)

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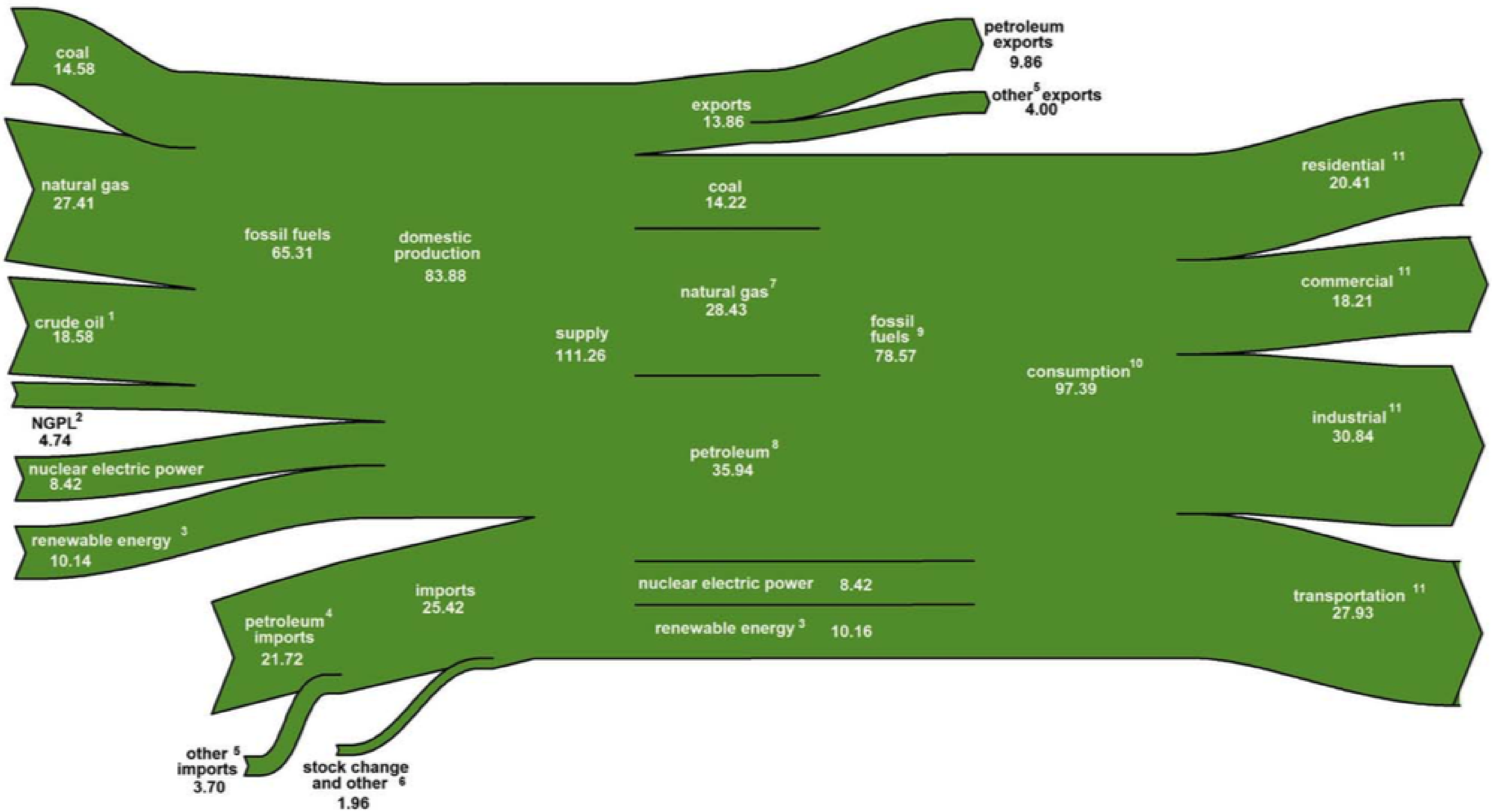
U.S. energy flow, 2016
quadrillion Btu



[1] Includes lease condensate.
[2] Natural gas plant liquids.
[3] Conventional hydroelectric power, biomass, geothermal, solar, and wind.
[4] Crude oil and petroleum products. Includes imports into the Strategic Petroleum Reserve.
[5] Natural gas, coal, coal coke, biofuels, and electricity.
[6] Adjustments, losses, and unaccounted for.
[7] Natural gas only; excludes supplemental gaseous fuels.
[8] Petroleum products, including natural gas plant liquids, and crude oil burned as fuel.
[9] Includes -0.02 quadrillion Btu of coal coke net imports.
[10] Includes 0.24 quadrillion Btu of electricity net imports.
[11] Total energy consumption, which is the sum of primary energy consumption, electricity retail sales, and electrical system energy losses. Losses are allocated to the end-use sectors in proportion to each sector's share of total electricity retail sales. See Note 1, "Electrical System Energy Losses," at the end of U.S. Energy Information Administration (EIA), *Monthly Energy Review* (April 2017), Section 2.

Notes: • Data are preliminary. • Values are derived from source data prior to rounding for publication. • Totals may not equal sum of components due to independent rounding.

Sources: EIA, *Monthly Energy Review* (April 2017), Tables 1.1, 1.2, 1.3, 1.4a, 1.4b, and 2.1.

https://www.eia.gov/totalenergy/data/monthly/pdf/flow/total_energy.pdf

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Solar 1.2×10^5 TW total
600 TW actual

Wind
2-4 TW
extractable

Tide/Ocean currents
2 TW gross

Geothermal
12 TW gross

Biomass
5-7 TW gross
(all cultivable land not used for food)

Hydroelectric
4.6 TW gross
1.6 TW feasible

Global Energy Consumption:	15 TW in 2008
Energy gap:	+ 10 TW by 2030
	+ 30 TW by 2100

http://nsl.caltech.edu/energy.html

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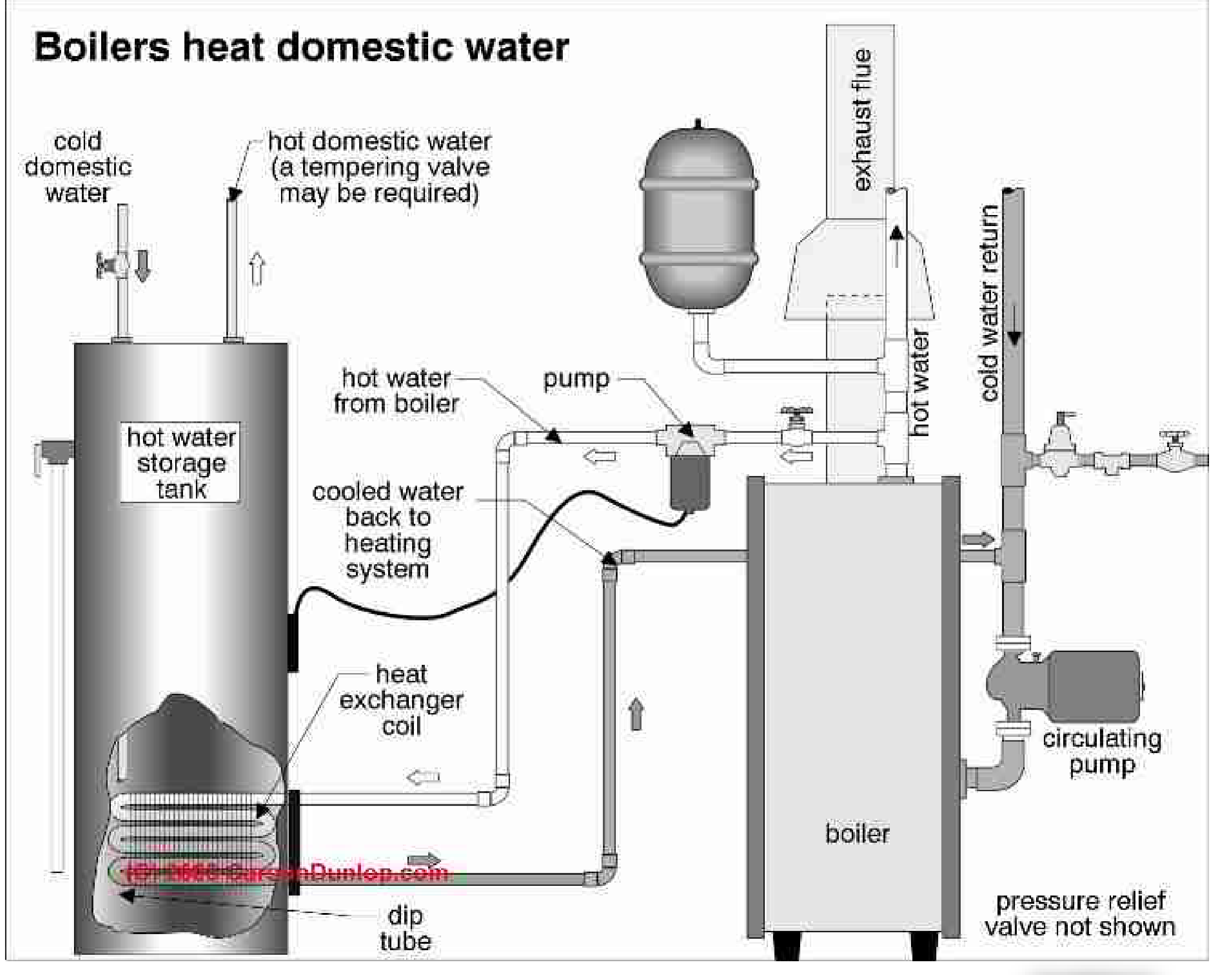
Current Alternative Heating Technologies

- Solar Panel
  - Electric (PV) - usually batteries for lights, fridge etc.
  - Hot Water - 70’s style pre-heating system
- Wind
  - Electric - batteries, could heat an element for water
  - Mechanical - siphon/pump used for elevating water
- Geothermal - home heating or energy production via steam

EXAMPLE OF A CONVENTIONAL HYDRONIC HEATING SYSTEM

- The water is taken from the street or well, and pulled into a boiler of some kind (closed or open-loop system).
- The system shown is used for both drinking water and as a heating system.

**Not usually equipped for alternative heat source.*



EXAMPLE OF A CONVENTIONAL ALTERNATIVE WATER HEATING SYSTEM

- If there is not enough sun, then conventional heat will be needed (oil, propane).
- Evacuated tubes greatly increased the thermal efficiency in northern latitudes, making it plausible to heat solely from solar hot water.